HOW TO WRITE A LAB REPORT

Science is a process in which individual scientists develop ideas and then, through the medium of scientific journal articles, seek to convince the scientific community that their ideas/theories are valid. Learning how to communicate your ideas effectively is a very important skill for a scientist (and is useful in many other professions as well).

As a result, you need to know how to describe the science that you do in a way that convinces the reader that your work is interesting and should be taken seriously. At the moment, you may feel that comparing your lab work/reports to the "real" science that appears in science journals a bit unjustified as we are probably not going to have you do much "cutting-edge" physics in this introductory physics course. The purpose of the lab reports though is to give you practice in writing scientific reports so that you'll be able to do it well when you do do "cutting-edge" work. ☺

A complete paper follows the following format:

TITLE PAGE

ABSTRACT

I. INTRODUCTION

II. THEORETICAL BACKGROUND

III. EXPERIMENTAL DESIGN AND PROCEDURE

IV. OBSERVATIONS

V. ANALYSIS

   a. Method of analysis
   b. Presentation of results
   c. Discussion of results
   d. Suggestions for future improvements

VI. CONCLUSIONS

The format provides some shortcuts for busy (or lazy) people. Readers like to find out in a hurry if a paper is actually of interest or importance to them. The *abstract* section provides a summary of the article and its most important results, so the reader only has to read a few sentences to determine if the entire paper is relevant to them. The *introduction* and *conclusions* contain a little more information – usually the reader goes to the introduction for more information about the purpose/method behind the experiment, and the conclusion for more detail on the results summarized in the abstract.

Each of the above sections is discussed on the pages that follow. You are encouraged to read the entire paper before you write your first lab report in the course. Then, throughout the semester, you can refer to the individual sections as needed.

Title Page

The title page should include the following information – a descriptive title, your name, the name(s) of your partner(s), the course title, and the date. An abstract should appear four lines below the date and have the heading ABSTRACT.

Abstract

The abstract must be able to stand by itself, it must be brief, and it must include the principal numerical results (if any) of the experiment. Its purpose is to help a reader to quickly decide whether or not your report is of significant interest for him/her to continue reading. If you were beginning a research project, one of the first things you would do would be to read the abstracts of recent articles that might be helpful – you only have so many hours in the day and good abstracts make it possible to determine *quickly* which articles are relevant to the work you wish to pursue. Its structure generally consists of three parts:

- ☐ What did you do
- ☐ What were your results
- ☐ What do these results tell you

A sample abstract is provided for you below. See if the abstract addresses the requirements listed above.

The behaviour of two different coffee-filters, one small and one large, was studied by measuring the time of travel as the filters were dropped from different heights. Results show, within the limits of accuracy of the experiment, that both filters travelled at a uniform rate with the larger filter travelling slower than the smaller filter. This is in agreement with the laws of physics pertaining to forces and motion.

Introduction

The introduction indicates the primary thrust or purpose of the experiment without indicating the results. It does not have to stand by itself and may refer to later parts of the report such as a diagram or a graph. Such reference should be numbered.

The introduction should include:

- ☐ theory to be tested or purpose
- ☐ the quantities to be measured
- ☐ assumptions under which the experiment is to be done
- ☐ expected results

Again, see if the introduction below addresses the above criteria.

When objects are in motion, they exhibit either uniform motion or accelerated motion. Position-time graphs that produce a constant slope indicate that the motion was uniform. To see whether or not a falling coffee filter underwent uniform or accelerated motion, the filter was dropped from different heights and the time of fall from each height was measured. The resulting data was used to plot a position (height) vs time graph. It was assumed that the filter was released from rest for each trial and that it fell vertically downward, that is, it did not sway side to side and that the distance travelled was the same each time. It was expected that the data would indicate uniform motion as air resistance would greatly impact the object's ability to accelerate.

Theoretical Background

It is very important that the theory section be written for the particular audience for which the report is intended. We will consider, for our lab reports, the audience to be one of your classmates who had to miss this lab.

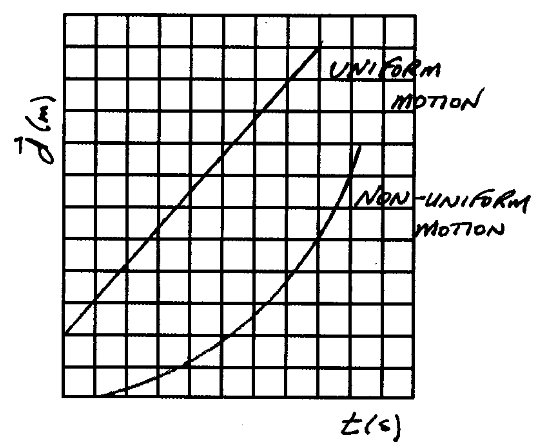
The theory section is meant to provide the reader with enough mathematical or theoretical background to understand how the experiment works, what assumptions have been made, and how the experiment is related to the physics being studied. Start with basic defining equations, and show all, non-obvious intermediate algebraic steps. Clearly identify any assumptions or approximations made. An example is provided below:

Any object, undergoing free-fall motion, is falling solely under the influence of gravity. According to Newton's 2nd Law, an object falling under such conditions will accelerate. [Nelson, p. 71] The strength of the gravitational pull on the object is equivalent to the objects weight, F_g, and this strength is determined by

$$F_g = mg \qquad (1)$$

where 'g' is the gravitational field strength constant: 9.8 N/kg and 'm' is the object's mass, in kilograms.

Air resistance, F_{air}, is a force that acts against the direction of an object's motion. As the speed of an object increases, so does the magnitude of the air resistance it experiences. Imagine cruising at 20 km/h with your hand out the car window – you can feel the air rushing past your hand. Now imagine travelling at 80 km/h – a great deal of effort is required on your part to prevent the F_{air} from pushing your hand towards back of the car. The air resistance has become much greater.



The speed of the falling coffee filter is very low early in its flight. It thus has very little air resistance. Since the force of gravity is greater than the air resistance, the filter accelerates as per Newton's 2nd Law. However, as it picks up speed it too experiences greater air resistance.

Soon F_{air} is of the same order of magnitude as F_g; as these forces act in opposite directions they cancel each other out and the object ceases to accelerate. According to Newton's 2nd Law, the forces are balanced and thus the motion is now uniform. The speed at this moment is known as 'terminal velocity'.

Given the very small mass of the filter, this occurs very early in its flight and thus, for the most part, the motion is uniform. A plot of position (height) vs time would result in a linear graph, the slope of which represents the speed with which the object was moving. An example of a position-time graph depicting uniform motion is shown in the margin.

The larger filter has slightly more mass and thus its weight is greater (equation 1) but its larger surface area allows the air resistance to be much greater at a lower speed. This means then that the object would accelerate for a smaller period of time and thus would reach uniform motion sooner – it would have a smaller speed. Thus, in theory, the larger filter should have a smaller terminal velocity than the smaller filter as they fall.

Experimental Design and Procedure

List the materials used in the experiment. If necessary, a sketch/diagram of the set-up is given enhance the ability of the reader to set-up and repeat your experiment.

The procedure elaborates on the part of the abstract that indicates "What did you do". The procedure is not a step by step series of instructions. It summarizes what was done yet provides enough information so that the experiment may be repeated by others. It is written in past tense and passive voice.

A ruler was placed, vertically, along a wall and the height from which the filters were to be dropped was measured. The time for each filter to fall from this position to the floor was measured using a stopwatch. Several trials were repeated from the same drop height and the average time of fall was determined. The process was repeated for different drop heights.

Observations

This section of the report includes any data which you measured and/or observed. No inferences appear here. Tables and graphs have numbers given to them although the graphs appear in the analysis section.

Table 1 ***Fall times as a function of height for various coffee filters***

Height (inches)	Small Filter Time Trials (s)						Mean Time (s)		Large Filter Time Trials (s)						Mean Time (s)
64	1.53	1.43	1.30	1.37	1.39	-	1.40		2.10	2.22	1.96	2.14	-	-	2.10
59	1.20	1.53	1.40	1.30	1.40	1.31	1.36		1.84	1.84	1.89	-	-	-	1.85
46	1.25	1.13	1.08	1.06	1.05	0.95	1.09		1.50	1.51	1.65	1.70	1.53	-	1.58
40	0.86	0.98	0.91	0.92	0.97	-	0.93		1.53	1.34	1.45	1.47	1.46	-	1.45
32	0.92	0.81	0.82	0.88	0.92	-	0.87		1.31	1.26	1.23	1.34	1.16	1.16	1.24
26	0.92	0.93	0.70	0.76	0.78	-	0.82		1.11	1.16	1.09	1.16	1.07	-	1.12

Analysis

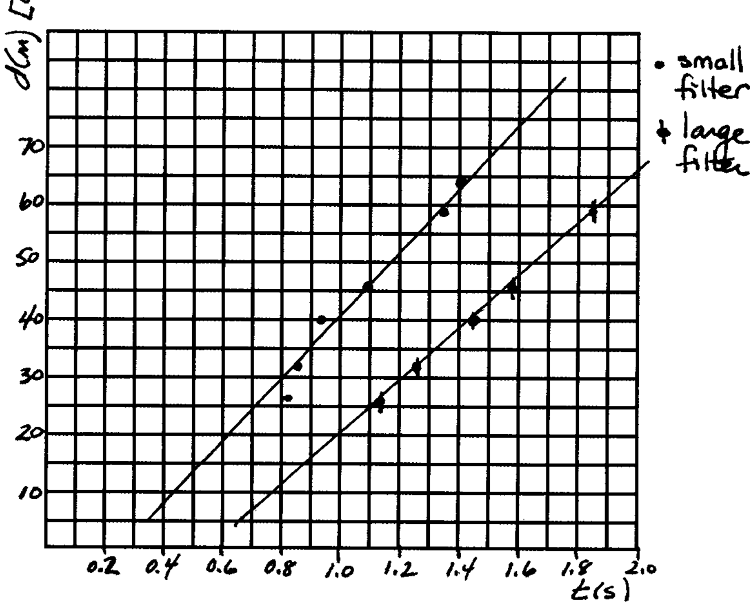
The analysis elaborates on the third part of the abstract: what do the results tell you? A sample analysis appears below.

A plot of position (height) vs time for both filters (Figure 1), results in straight lines indicating uniform motion for both filters. Based on the theory discussed, both filters reach a constant velocity very soon into their flight. Data was not recorded for drop heights of less than 25 cm as it became apparent that reaction-time (the time to start and to stop the stopwatch) would interfere with the actual time of flight.

The speed for each coffee filter was determined by calculating the slope of each line. The speed of the small coffee filter was determined to be 66.7"/s (1.69 m/s) and that of the large coffee filter was determined to be 43.75"/s (1.11 m/s).

The lines of best fit do not intersect the origin. This may be attributed to experimental error.

Figure 1 ***Position vs time for falling coffee filters***



The data was gathered from a number of different groups, each conducting the experiment from different heights. It is possible that the filter was not released from the exact position (height) measured and it is also possible, that on release, the filter was given either an upward or downward initial velocity. Reaction times in starting the stopwatch at the moment of release as well as stopping the stopwatch at the moment of impact may too have attributed to this error. Ensuring that all the data came from one group of students and that several more trials were conducted from each drop height would enable one to minimize the error.

Based on the above analysis you should be able to see that an analysis should:

- ☐ briefly discuss the data
- ☐ discuss graphs
- ☐ discuss consistency or lack thereof with any theoretical predictions
- ☐ shows how you calculated any numerical values (obvious ones excluded)
- ☐ discusses the results and their implications
- ☐ discusses potential sources of error

Conclusion

Briefly summarize everything!

All objects accelerate as the fall. However, due to the significant impact of air resistance on the motion of the coffee filters, the filters fall at a uniform rate for much of the duration of their flight.

Bibliography

Use the APA style found in "On Your Own" to indicate the sources consulted.

ON THE TOPIC OF ORIGINALITY

Students benefit from study groups, learning from each other. That said, strongly resist the temptation to rely too heavily on others to analyze your data. When exam time comes, you will be working alone.

Lab partners discuss each experiment and share ideas. Your report, however, represents your own work and not that of the group. Don't let others do all your thinking and analysis.

Partners' data, of course, will consist of the same set of numbers, but each partner will organize the report to suit his or her own personal tastes and style. Each will do the data analysis independently. Partners' reports will, therefore, not look alike, even superficially. When partners' or classmates make identical mistakes, this raises suspicions that one must have copied without thinking. Don't plagiarize. Better to make your own mistakes, honestly, and to then learn from them. When you write the discussion of the results yourself, you will gain the valuable experience of drawing your own conclusions, unprejudiced by the opinions of others.